EEE 313 - Electronic Circuit Design - Lab 3 Preliminary Report
Tuna Şahin - Single-Supply Push-pull Class-B Power Amplifier

Introduction:

For this lab, we were asked to design a Single-Supply Push-Pull Class-B Power Amplifier. In order to do so, we used a complementary BJT approach. My Bilkent ID is 22201730, so I was asked to implement the amplifier with a gain of 20 + mod(22201730,7) = 25dB.

Calculations:

1. We needed to choose $C_5 \ll R_L$ at 150Hz. To do so we evaluated the following inequality. $\frac{1}{jwC} < 33\Omega$, Choosing $C_5 = 270\mu F$ allowed us to get $X_C \simeq 24\Omega$ at 150Hz.

2. We needed to choose R_2 and R_3 so that $I_C(Q4) = 10I_{R3}$

   $I_{R3} = \frac{R_3 I_{R3} - 24}{R_2} - I_B$ and $I_B = V_{CC} - V_{BE} - 27(\beta + 1)I_B - I_{R3}R_3$ and $\beta I_B = 10I_{R3}$

   Arbitrarily choosing $R_2 = 1k$ and solving these equations gives us $R_3 \simeq 22k$

3. Assuming $V_{BE} = 0.7$ we need to choose R_{10} and R_{11} such that:

   $$1 \leq (1 + \frac{R_{10}}{R_{11}})0.7 \leq 1.1 \Rightarrow 0.428 \leq \frac{R_{10}}{R_{11}} \leq 0.571$$

   I chose $R_{10} = 2.7k$ and $R_{11} = 5.6k$ so $R_{10}/R_{11} = 0.5$

4. R_4 and R_5 control the gain of the Opamp. They are chosen as $R_5 = 1.5k$ and $R_4 = 27k \parallel 450k$

LTSpice Simulations:

Our designs had some criteria they needed to satisfy.

1. The amplifier should deliver at least 0.95W power to a 33Ω resistance (16Vpp to a 33Ω power resistor) at 1KHz with the chosen gain value.

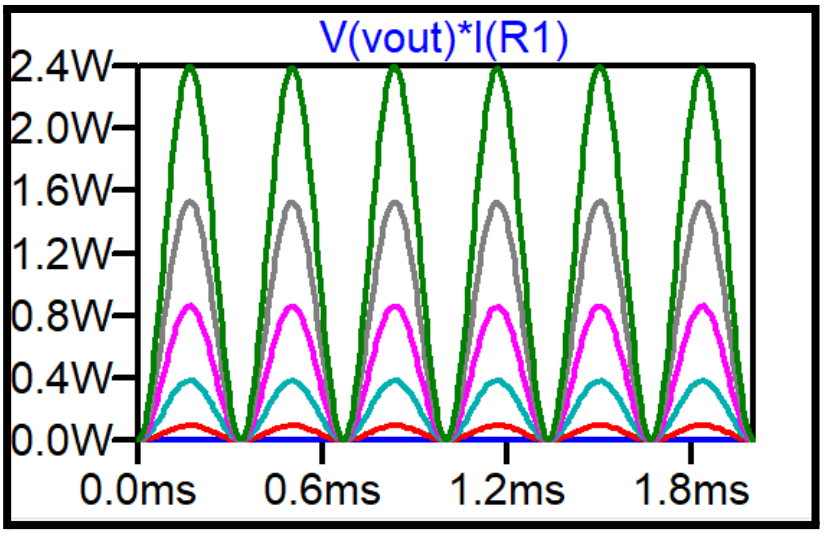


Figure 1.1: Load Power Consumption

The circuit can deliver up to 2.4W to the load at 1kHz.

2. The harmonics (the highest is possibly the third harmonic) at the 0.95W output power level should be at least 40 dB lower than the fundamental signal at 1 KHz.

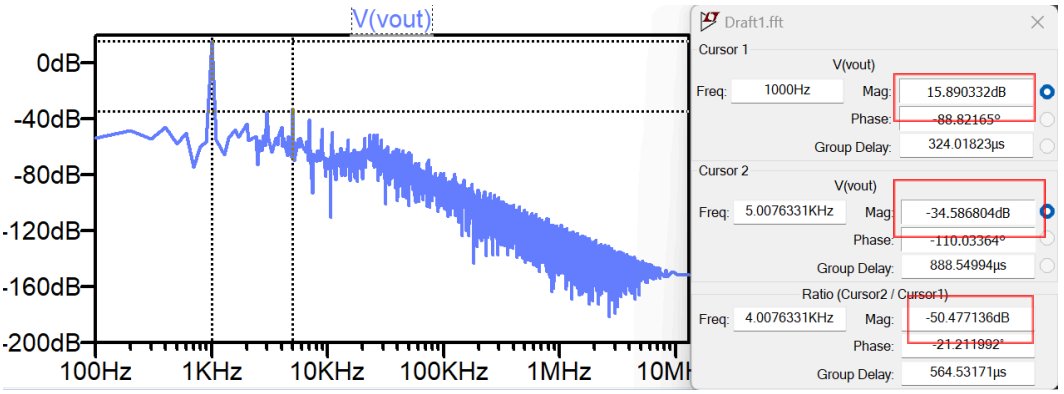
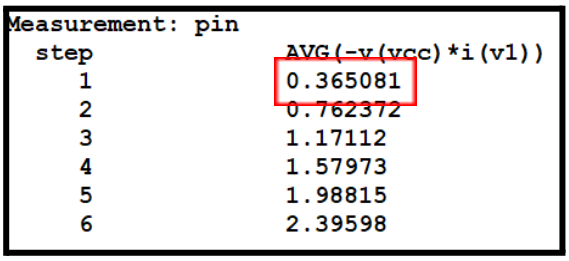


Figure 1.2: FFT of V_{out}

The third harmonic, which was indeed the highest, is 50dB lower than the fundamental harmonic.

3. The power consumption at quiescent conditions should be less than 500mW.

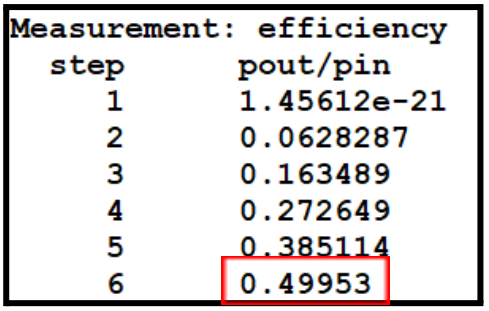


Measurement: pin	
step	AVG(-v(vcc)*i(v1))
1	0.365081
2	0.762372
3	1.17112
4	1.57973
5	1.98815
6	2.39598

Figure 1.3: P_{in} when $V_{in} = 0$

The quiescent power consumption is 360mW. (when $V_{in} = 0$

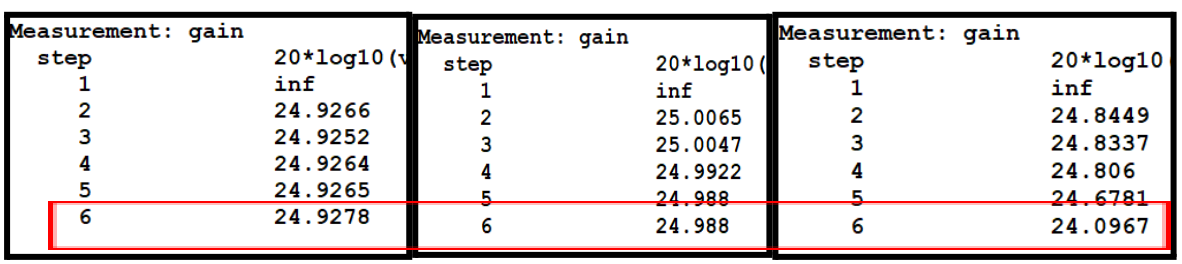
4. The amplifier's efficiency (output power/total supply power) should be at least 40% at max power output (0.95W) at 1KHz.



Measurement: efficiency	
step	pout/pin
1	1.45612e-21
2	0.0628287
3	0.163489
4	0.272649
5	0.385114
6	0.49953

Figure 1.4: Efficiency at max power

5. The −3dB bandwidth of the amplifier should be at least 150Hz to 15KHz.a



Measurement: gain	
step	20*log10(v
1	inf
2	24.9266
3	24.9252
4	24.9264
5	24.9265
6	24.9278

Measurement: gain	
step	20*log10(
1	inf
2	25.0065
3	25.0047
4	24.9922
5	24.988
6	24.988

Measurement: gain	
step	20*log10
1	inf
2	24.8449
3	24.8337
4	24.806
5	24.6781
6	24.0967

Figure 1.5: Gain values at $f = 150Hz$, $f = 1kHz$, $f = 15kHz$

The gain at 150Hz, 1kHz, 15kHz is 24.92dB, 25dB, and 24dB respectively.

LTSpice Schematic:

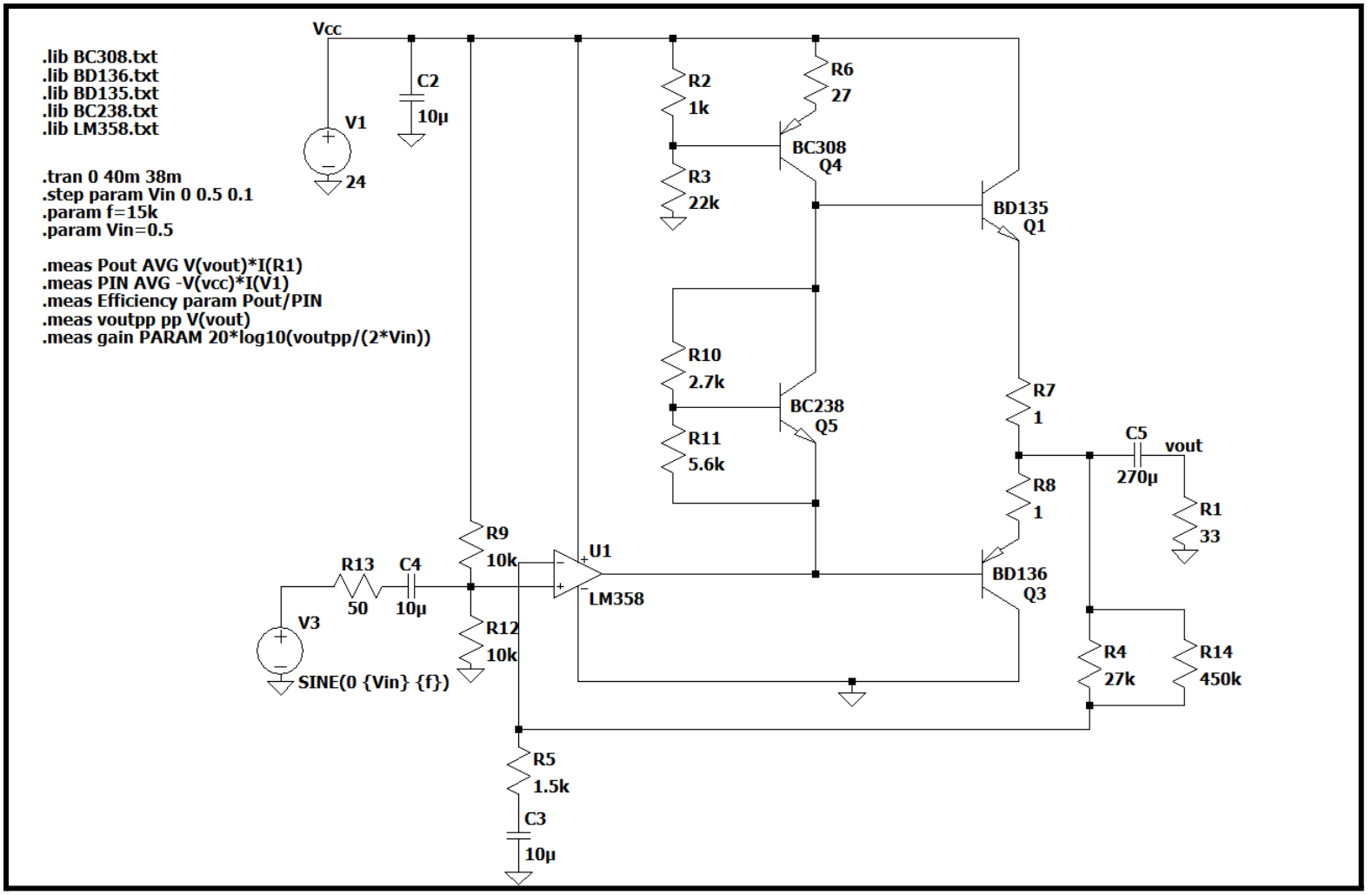
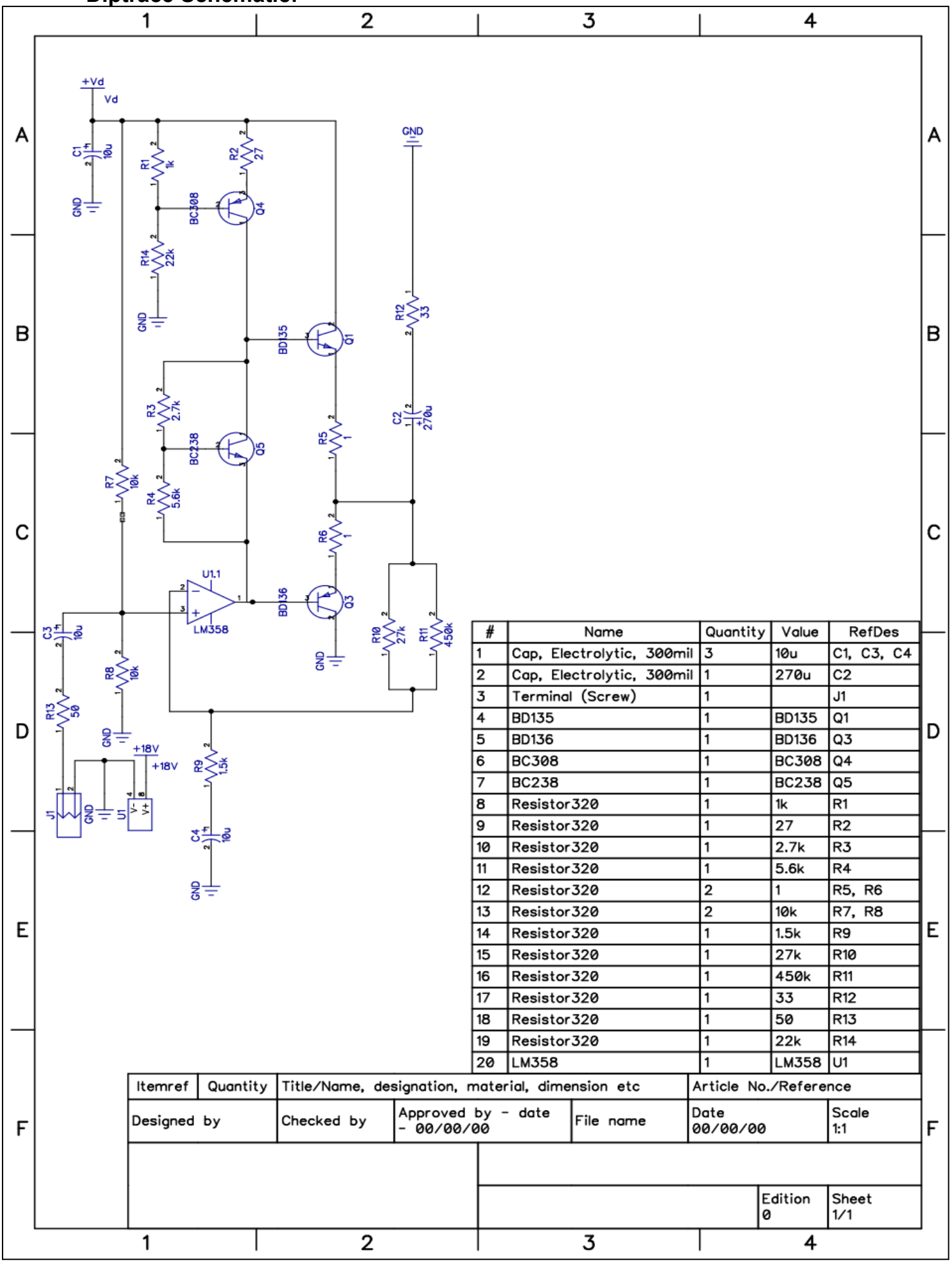


Figure 2: LTSpice Schematic

Diptrace Schematic:



#	Name	Quantity	Value	RefDes
1	Cap, Electrolytic, 300mil	3	10u	C1, C3, C4
2	Cap, Electrolytic, 300mil	1	270u	C2
3	Terminal (Screw)	1		J1
4	BD135	1	BD135	Q1
5	BD136	1	BD136	Q3
6	BC308	1	BC308	Q4
7	BC238	1	BC238	Q5
8	Resistor320	1	1k	R1
9	Resistor320	1	27	R2
10	Resistor320	1	2.7k	R3
11	Resistor320	1	5.6k	R4
12	Resistor320	2	1	R5, R6
13	Resistor320	2	10k	R7, R8
14	Resistor320	1	1.5k	R9
15	Resistor320	1	27k	R10
16	Resistor320	1	450k	R11
17	Resistor320	1	33	R12
18	Resistor320	1	50	R13
19	Resistor320	1	22k	R14
20	LM358	1	LM358	U1

Itemref	Quantity	Title/Name, designation, material, dimension etc		Article No./Reference	
Designed by		Checked by	Approved by - date - 00/00/00	File name	Date 00/00/00	Scale 1:1
					Edition 0	Sheet 1/1